SOCIETAL IMPACTS OF SPACE WEATHER (T-11)

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Space weather is all around us yet it is difficult for the average person to understand its nature and to assess its impacts on everyday life. The ancient Nordic people were captivated and, at times, in fear of the aurora borealis which is perhaps the most dramatic and clear manifestation of space weather. As society's dependence on high-technology systems has increased, so too has its vulnerability to space weather. In 1859 a truly remarkable solar flare erupted off the surface of the sun that, in the current parlance of space weather, was extremely geo-effective and had a major impact on the Nation's telegraph network. More recently we have learned the hard way that space weather can have debilitating impacts on the electric power grid, wireless communications, geo-positioning and navigation, man-in-space and satellite operations. In this talk I will trace the history of space weather and its impacts on society. I will also discuss how NOAA is responding to the threat of hazardous space weather by monitoring the solar and near-earth space environment and by forecasting conditions that can have deleterious effects on our way of life.

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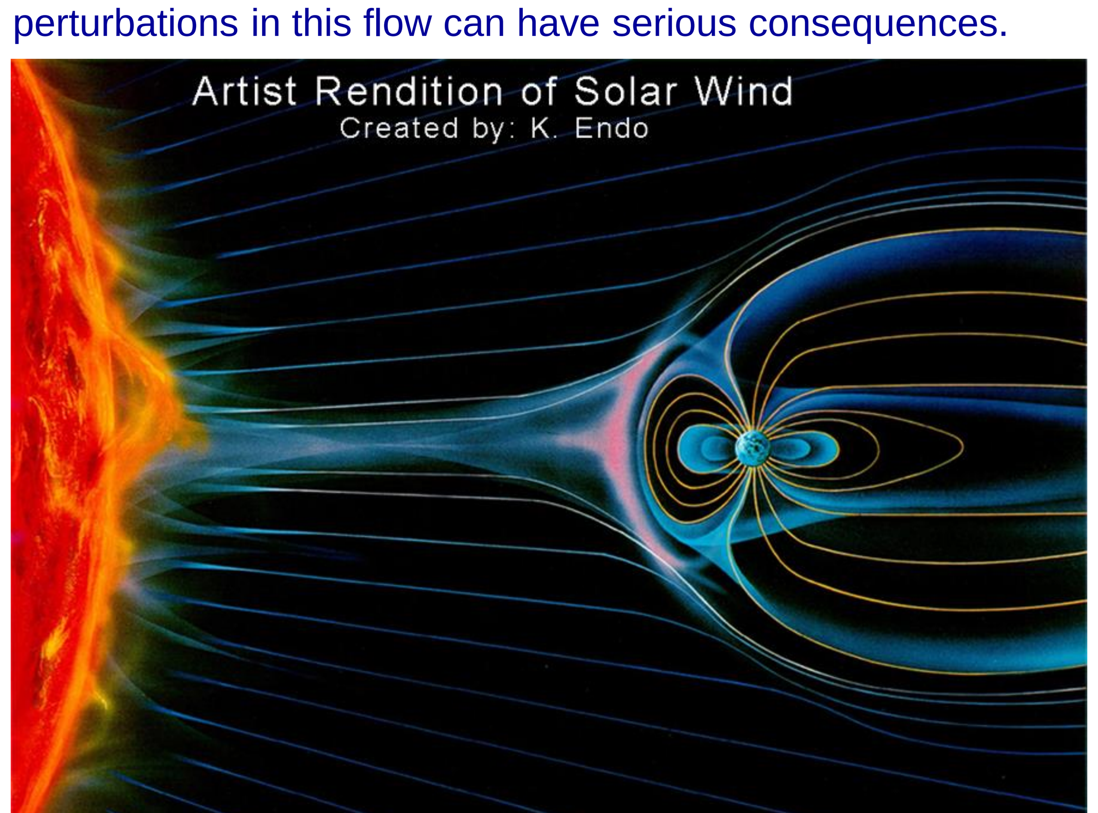
BACKGROUND

The auroral borealis is a beautiful and awe-inspiring example of space weather. These northern lights are the result of energetic charged particles entering the atmosphere from deep space and interacting with neutral gases at altitudes above 100 kilometers. Ancient civilizations of the north were deeply concerned about the rays of light that seemed to undulate and dance across the night sky. In Norway legend had it that the mysterious lights were a harbinger of evil that would try to harm their children if they were caught outside.

Auroral over Fairbank, AK (photo credit Jim Spann/NASA

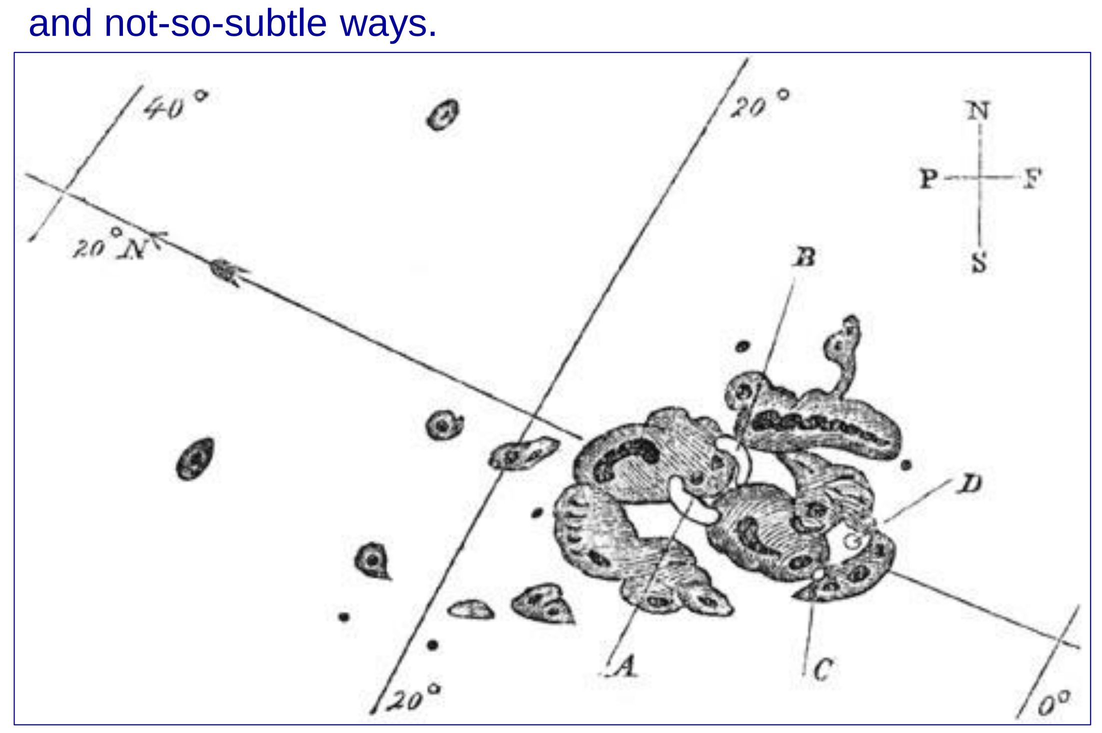
Our understanding of the aurora has greatly improved since the time of the ancients. We now know that the aurora is just one tell-tale indicator of the consequences of events that originate at the sun and affect the local geo-space as space weather. The sun constantly spews energy and mass in the forms of both electromagnetic radiation and charged particles. The earth is protected to a large degree from the constant stream of solar energetic particles by a magnetic field that tends to divert this particulate radiation. However, perturbations in this flow can have serious consequences.



Solar-Terrestrial Relations

1959 CARRINGTON EVENT

Richard Carrington was an English amateur astronomer who first recognized the causal relationship between solar flares and terrestrial effects. On 01 September 1859, a major solar flare and resultant Coronal Mass Ejection (CME) occurred on the surface of the sun that ripped through interplanetary space on a direct collision course with earth. The large geomagnetic storm following this solar event had a major impact on the technology system of the day; namely, telegraph communications. Operators reported that telegraphs cracked and sizzled as induced currents (as we now know them to be) flowed through the system. Auroras as far south as the Caribbean were observed during what has been classified as the "Perfect Solar Storm". As technologies have advanced and our dependence on them increased, we have become more vulnerable to space weather effects. A recent (2008) report from the National Research Council (NRC) found that the financial impact of a Carrington-like event could reach 2 trillion dollars. Aside from such a life-altering event, space weather impacts our daily lives in subtle and not-so-subtle ways.

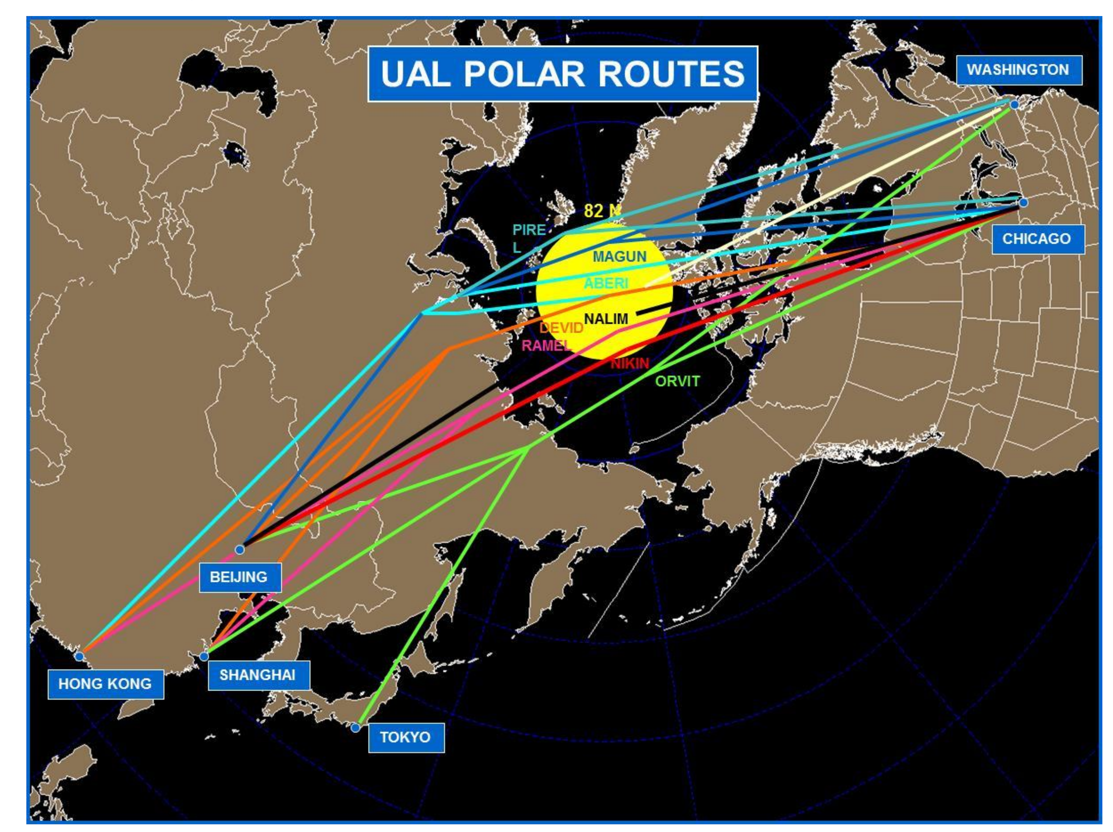


Carrington solar flare observations, Sept 1, 1859

In March 1989, a large geomagnetic storm was responsible for an electrical power outage that affected vast portions of Quebec leaving some 6 million people in the dark for 9 hours. The estimated cost of this significant, but not overly extreme, storm (compared to the Carrington event) had an estimated cost of $300 million.

Power Transformer Damage Attributed to Space Weather

Another geo-effective event occurred in Oct-Nov 2003 which plunged the Swedish city of Malmo into darkness affecting some 250,000 residents. This "Halloween" storm was notable in that several near-Earth spacecraft suffered service disruptions, component damage, or complete mission failure as was the case for the Advanced Earth Observing Satellite 2 (ADEOS 2), also known as Midori-2. Other impacts reported in a NOAA Service Assessment stated that "the global effects of this storm were wide-ranging, impacting power grids, airline flights, spacecraft operations, and much more."



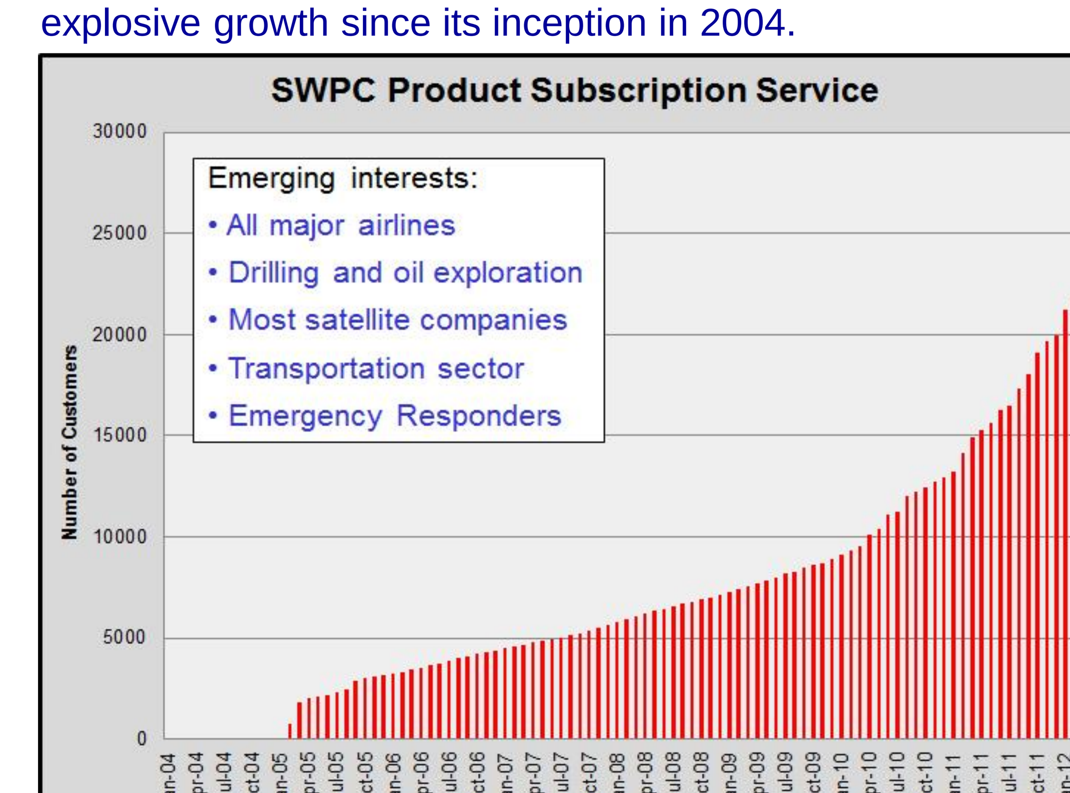
Commercial polar routes used by United Airlines

The commercial aviation impacts noted in the last paragraph are indicative of the systemic effects of space weather. Between 2000 and 2005, the number of cross polar flights increased a factor of ten-fold from 369 to 3731. On numerous occasions pilots had to divert to lower latitudes due to the loss of communication and increased radiation at a cost of $100,000 per incident. Relatedly, manned spaceflight is affected by space weather and during times of heightened space weather astronaut activities are curtailed or cancelled due to the risk of radiation exposure.

Also noted earlier were the causal effects of space weather on satellite operations. In April 2010, the Galaxy-15 geostationary communication satellites experienced a space weather related anomaly that rendered the satellite useless for almost 8 months. What was particularly interesting in this event is that the Galaxy-15 continued to broadcast unabated with no ground control while it migrated out of its designated satellite slot region. As a result, Galaxy-15 was whimsically dubbed a "Zombie-Sat" in that other communication satellites had to be re-positioned to avoid signal interference. A space environmental assessment conducted jointly by the NOAA National Geophysical Data Center and the Space Weather Prediction Center found that the space weather conditions at the time were not extreme but that various contributing factors were responsible for the anomaly – a typical case of the satellite being in the wrong place at the wrong time.

Galaxy-15 communications satellite – 05 Apr 2010

NOAA continuously monitors the sun and the near-earth space environment at its forecast office within the NWS Space Weather Prediction Center (SWPC) in Boulder CO. SWPC issues alerts and warnings to advise technology-dependent users of deleterious space weather conditions. Forecasters use data from NOAA's fleet of operational spacecraft in polar orbit and geostationary orbit as well as positioned along the earth-sun line at L1 (240 R_E). Interest in subscription services for space weather products has shown explosive growth since its inception in 2004.



Growth profile for SWPC subscription services.

Concluding remarks

As society becomes more dependent on advanced technology systems so too does its vulnerability to space weather. NOAA is well positioned to provide space environmental data and products in the form of analyses and forecasts that can be used to mitigate space weather and to build more environmentally resilient systems. The NESDIS National Geophysical Data Center and the NWS Space Weather Prediction Center are teamed to provide these space weather services now and in the future.